DOCUMENTATION OF DECISION-AIDING SOFTWARE:

DECISION USERS MANUAL

DECISIONS AND DESIGNS INC.

Linda B. Allardyce
Dorothy M. Amey
Phillip H. Feuerwerger
Roy M. Gulick

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DOCUMENTATION OF DECISION-AIDING SOFTWARE:
DECISION USERS MANUAL

by

Linda B. Allardyce, Dorothy M. Amey, Phillip H. Feuerwerger, and Roy M. Gulick

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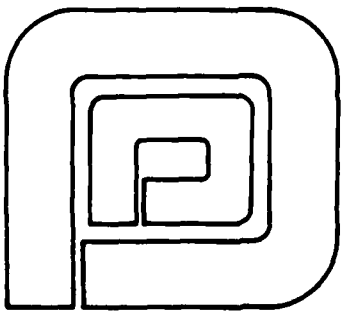

DECISIONS and DESIGNS, INC.
Suite 600, 8400 Westpark Drive
P.O.Box 907
McLean, Virginia 22101
(703) 821-2828

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DECISION USERS MANUAL

1.0 INTRODUCTION

1.1 Purpose of the Users Manual

The purpose of this manual is to provide users of the DECISION software system with the background material and the detailed instructions necessary to use and interpret the various functions that DECISION provides. The manual also presents the decision-analytic concepts inherent in the decision tree modeling approach, including the assumptions and restrictions concerning its use. The manual includes case study applications.

Because the manual must serve users both skilled and unskilled in the use of decision-analytic methodology, it is prepared in a modular fashion. Thus, whereas the initial sections provide detailed information for the naive user, the last section is direct and unelaborated for those users knowledgeable in the approach.

1.2 References

1.2.1 Barclay, Scott, et al. Handbook for Decision Analysis. Technical Report 77-6-30. McLean, Virginia: Decisions and Designs, Inc., September 1977.

1.2.2 Gulick, Roy M. Documentation of Decision-Aiding Software: Introductory Guide. Technical Report TR 79-1-93. McLean, Virginia: Decisions and Designs, Inc., in press.

1.2.3 Amey, Dorothy M.; Feuerwerger, Phillip H.; Gulick, Roy M. Documentation of Decision-Aiding Software: DECISION Functional Description. McLean, Virginia: Decisions and Designs, Inc., November 1979.

1.2.4 Amey, Dorothy M.; Feuerwerger, Phillip H.; Gulick, Roy M. Documentation of Decision-Aiding Software: DECISION System Specification. McLean, Virginia: Decisions and Designs, Inc., November 1979.

1.3 Terms

1.3.1 DECISION - DECISION, the name of the system, reflects the system's major area of applicability: building and exercising decision tree models of complex decision problems.

2.0 SYSTEM SUMMARY

2.1 Background

Complex, important decision problems require sound decision making in the face of inconclusive evidence, conflictive goals and unclear personal judgments. In solving such problems, the decision maker's objective is to choose that course of action which is most consistent with the assessments of the evidence concerning the outcome of future events and judgments concerning the satisfaction of goals.

In most important decision problems the decision maker is operating under a severe time constraint and with incomplete information, so that unusual pressures bear on the entire decision-making staff and the opportunities for misperception, misunderstanding, and miscommunication abound. Those pressures and opportunities are magnified in crisis decision-making contexts. To minimize their effects, decision makers need to employ effective decision strategies to ensure that the ultimate decision choice is consistent with the intelligence assessments and the goals at hand.

One such strategy is to use a decision tree to model the problem. A decision tree model serves as a graphical organizing framework for processing the relevant information and judgment concerning the problem. Decision tree models aid the decision-making process by prescribing a straightforward, normative procedure for organizing, analyzing, and deliberating the various courses of action open to the decision maker.

The decision tree modeling procedure requires the user to decompose the decision problem into relatively simple

components that approximate the reality of the situation. The user, drawing on relevant information and experienced judgment, focuses upon and evaluates each component of the model separately. The DECISION software system assists the user in that process and then aggregates the separate judgments about each component into a global analysis and recommendation.

A simple decision tree model is shown in Figure 2-1. The model depicts a decision situation having two alternative courses of action: D_1 and D_2. The problem is to choose one of those alternatives. Presumably, the choice is irrevocable; characteristic of most important decisions, once the choice is implemented there is no turning back.

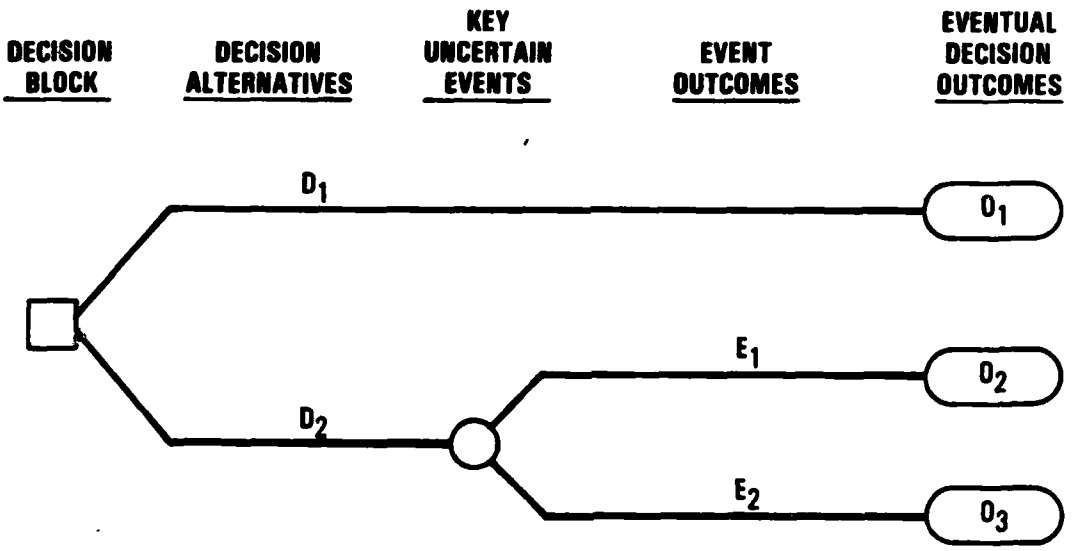

Figure 2-1
A SIMPLE DECISION TREE MODEL

The model shows that whereas course of action D_1 involves no uncertainty, D_2 involves a future uncertain event that will occur in one of two ways: either with outcome E_1 or with outcome E_2. The model indicates that the problem has three possible eventual outcomes: O_1, O_2, and O_3.

Even the relatively simple tree of Figure 2-1 can represent a very complex crisis decision-making situation. For example, it could represent the problem of deciding whether or not to order an evacuation of U.S. nationals from a foreign country. In that case, path D_1 would be the course of action to evacuate, path D_2 the course of action not to evacuate. Presumably, the outcome associated with evacuating is relatively certain (outcome O_1). However, a key uncertainty attaches to the course of action not to evacuate. The uncertainty might be that the recognized but threatened government either will hold power (E_1) or fall (E_2), leading to two vastly different outcomes (O_2 and O_3) for the choice not to evacuate.

The simple model of Figure 2-1 could, of course, be made more complex and more descriptive of the real situation by adding additional decision blocks, decision alternatives, events, and event outcomes. In any case, the model must be tailored carefully to fit the actual decision situation at hand. Figure 2-2 shows a more complex decision tree model with subsequent decision blocks and subsequent events that lead to twelve outcomes.

Once the model has been refined to the point that it becomes an acceptable representation of the problem, then its component parts can be analyzed individually and aggregated as discussed in the remainder of this manual.

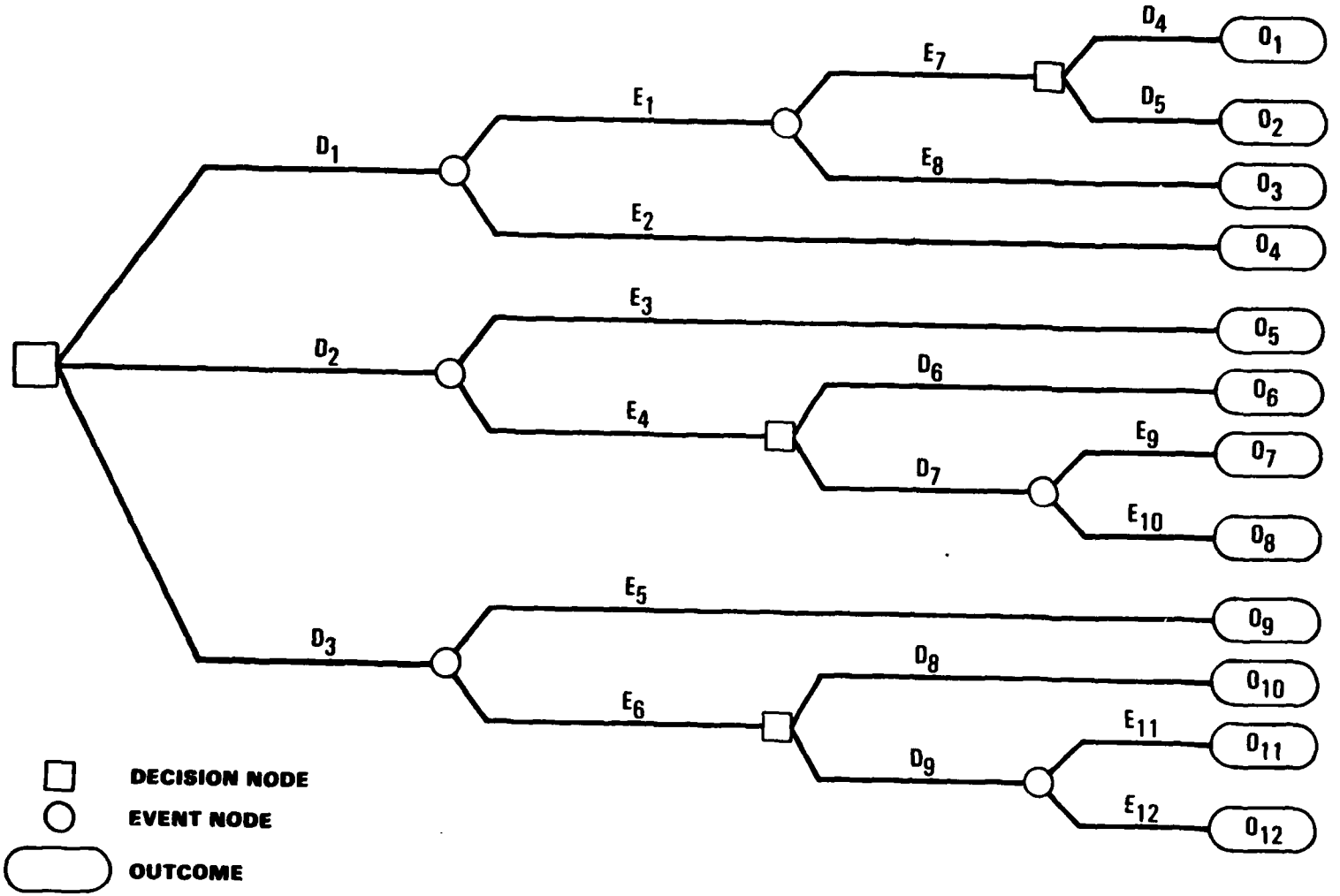

Figure 2-2

A MORE COMPLEX DECISION TREE MODEL

DECISION has its roots in the field of decision analysis, a management discipline that emerged in the mid-1960's. As described in reference 1.2.1, decision analysis has proven successful in aiding military decision-making processes across a broad spectrum of applications, including crisis decision making.

It must be emphasized that by no means does the use of decision analysis and DECISION replace human judgment; rather, the use of DECISION focuses, aids, and clarifies human judgment.

2.2 Objective

DECISION is a decision-analytic based, computer-assisted decision aid. The primary objective of the aid is to provide decision makers a procedural framework that will ensure that their ultimate decision choice is a coherent one: a course of action that is fully consistent with their goals, value structures, and beliefs about the relative likelihoods of future events that eventually will impact the outcome of the problem.

The fundamental product of DECISION is a conceptual computer-stored decision tree model of the decision problem at hand. Whereas the discipline of decision analysis provides the theoretical background and procedural guidance, the DECISION decision tree model provides the specific methodological tool for processing information and evaluating the various courses of action open to the decision maker.

The objective of the DECISION software system is to provide decision makers with the capability to construct, store, retrieve, exercise, and modify decision tree models.

The user who is inexperienced in decision analysis is cautioned that the DECISION software should not be applied indiscriminately, nor should its results be interpreted blindly. In particular, the prospective user must understand that a decision tree framework fits only those decision situations that meet all of the following characteristics:

- The decision problem is well formed; i.e., alternative courses of action, key uncertainties, and subsequent decisions have been identified and made explicit.
- A simple structural representation of the problem will suffice.
- The various criteria that will apply to the ultimate evaluation of the outcome of the problem have been identified.
- An ad hoc solution is appropriate.

2.3 Procedural Overview

The first step in problem solving using DECISION is to construct a conceptual decision tree model of the problem. Normally, the DECISION software is not used during the initial development of the model; rather, the modeling process begins as a trial and discovery process that involves several constructions using ordinary working procedures. The computer aid should be used only when the model has reached an advanced state of refinement.

A decision tree model always takes the same general format, as shown in Figures 2-1 and 2-2. The decision flow

always begins at the left of the diagram with a primary decision block. The decision maker is presumed to be faced with the primary decision at the time of the analysis. The logical flow then branches outward and to the right into the various decision alternatives available to the decision maker. The decision alternatives lead to nodes representing the key uncertainties faced by the decision maker. Continuing the flow to the right, the key uncertainty nodes branch outward into event outcomes which, taken together, define all of the various ways in which the key uncertainty could unfold. A subsequent decision block may follow the event outcomes, and the corresponding decision alternatives may themselves be followed by other uncertain events.

The logical flow eventually terminates at the far right of the diagram with the decision outcomes. Each decision outcome is a combination of the various decision alternatives and event outcomes defining the path from left to right.

Once the decision tree model is structured, the decision maker must provide two distinct kinds of value judgments: the probabilities of occurrence of each of the event outcomes, and the utility associated with each of the decision outcomes. Neither judgmental task is easy. The first is complicated by the various relationships among secondary events that will influence the outcome of each key uncertainty; and the latter is complicated by the multiple dimensions, usually subjective in nature, that comprise the decision maker's total expression of the utility associated with a decision outcome. For ease of assessment, the decision model permits the total utility to be determined by decomposing it into several specific criteria, each having an associated relative importance weight.

Once the user has completely specified the decision tree model to the DECISION software, the model can be exercised by the user to produce the value of the expected utility associated with each of the primary decision alternatives. The rational user should then choose that course of action that leads to the greatest expected utility.

2.4 Purpose of the Model

At this point it must be stressed that the purpose of a decision tree model is not to capture reality, but rather to approximate it. Structuring a decision tree is an art, and the practice of that art is attended by difficulties in selecting a representative set of decision blocks, decision alternatives, key uncertainties, and uncertain event outcomes. Specifying the attendant probabilities, criteria, and utilities is equally difficult. Ideally, an experienced professional decision analyst would work closely with the decision maker in structuring and specifying a decision tree model. In any case, the ultimate tests of a decision tree model should be:

a. Is the model free of obvious inconsistencies?

b. Does the model approximate the reality of the situation?

c. Is the model practical and useful to the decision maker?

d. Does the model provide insight to the decision maker and the staff?

3.0 STRUCTURING THE DECISION MODEL

To use the DECISION software, the user must first create a decision tree model. To facilitate understanding of the decision tree modeling process, this section uses a case study approach. Consider the following hypothetical scenario.

3.1 Hypothetical Crisis

For some weeks military analysts have been concerned with the apparent introduction of defensive surface-to-air and offensive surface-to-surface missiles into the tiny island country of Rambo.

The U.S. National Command Authority (NCA) believes that if the missiles have in fact been introduced into Rambo, they will be used against U.S. installations and aircraft. Consequently, the NCA is seriously considering three immediate courses of action (CA):

CA1 - RAID. Conduct a helicopter-borne night raid on Rambo; destroy all offensive weapons.

CA2 - WARN. Issue a stern warning to Rambo that the missiles must be removed within 48 hours.

CA3 - SEEK OUT AGENT. Establish contact with an agent in Rambo. The agent is considered 80% reliable. However, this is a very danger ous course of action; there is only an even chance that the agent will be contacted successfully.

3.2 Decision Tree Model

The decision tree model is always structured from left to right. The logical flow branches outward and to the right as each of the primary decision alternatives encounters future events having uncertain outcomes and subsequent decision choices are made available. The model terminates

on the right with the decision outcomes. The structure of a decision tree model follows the general format shown in Figures 2-1 and 2-2.

A decision tree model is composed of the following elements, each of which is illustrated by using the hypothetical scenario.

3.2.1 The primary decision block - A decision tree model always begins at the left with a primary decision block that represents the current point in time. The DECISION software requires that the user define a concise identifying label that uniquely describes the primary decision. The label is used by DECISION for model storage and retrieval purposes. RAMBO would be an appropriate label for the primary decision and the model.

3.2.2 Decision alternatives - The user must list the primary courses of action that are available to the decision maker. In the RAMBO crisis, three alternative courses of action have been defined: to raid, to warn, or to seek out an agent, as depicted in Figure 3-1.

There are five guidelines that pertain to the creation of the decision alternatives.

a. The list should be exhaustive. That is, it should include all of the alternatives that are under serious consideration. A key assumption here is that one of the alternatives on the list will in fact be chosen. In that regard, note that the alternative "not to decide yet" (to buy additional time or to purchase additional information, perhaps) is a perfectly legitimate alternative for inclusion on the list.

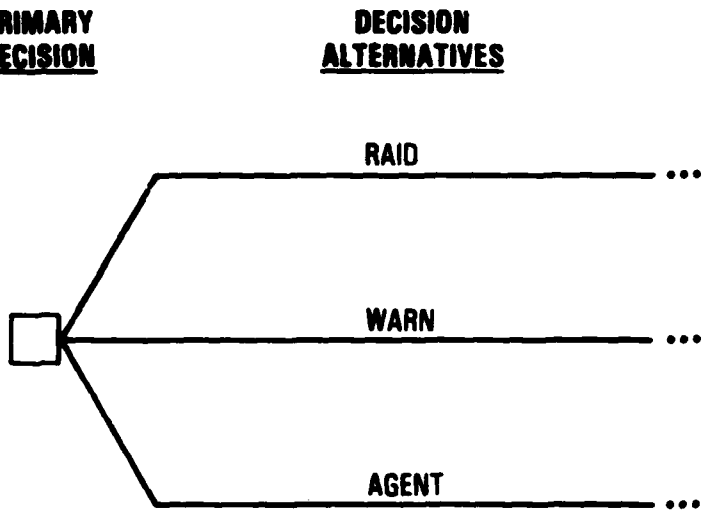

Figure 3-1
PRIMARY DECISION BLOCK

b. The list should also be exclusive; that is, the alternatives should be independent. The selection of one alternative should preclude the implied selection of another. This restriction, together with the previous one, ensures that one and only one of the alternatives on the list will ultimately be chosen.

c. The alternatives on the list should be reasonable ones. The list should not include any alternatives that are impossible to implement (because of time and space factors, for example) or that, although possible, are so impracticable that they would never be selected under any circumstance.

d. Similar alternatives should be combined where possible in order to reduce the total number of

choices to a reasonable length. Ten alternatives is an upper bound; three or four are preferred.

e. At this point, the short, refined list of decision alternatives should pose a true dilemma for the decision maker. Each one of the alternatives should have a strong appeal to the decision maker on at least one dimension of value. If not, if any alternative seems to have nothing at all to recommend it, that alternative should be removed from the list.

3.2.3 Key uncertainties - The next step in creating a decision tree model is to identify the key future events whose uncertain outcome will impact the eventual degree of success of the primary decision. In the RAMBO crisis, there are several key events. For example, if the decision maker decides either to raid or to warn, then there are three key uncertainties: whether or not there are missiles present, if there are missiles present whether or not they will be launched, and if they are launched, whether or not there will be damage to U.S. facilities. Figure 3-2 is a simple representation of the uncertainties for the RAID course of action. It applies equally well to the WARN course of action.

The list of outcomes for each of the uncertain events should be exhaustive, exclusive, reasonable, and relatively short. Again, the intent is not to capture reality, but rather to do a good job of approximating it.

3.2.4 Subsequent decisions - Certain outcomes of the key uncertainties may require that the decision maker choose among subsequent alternative courses of action. In the RAMBO case, for example, the primary decision choice to

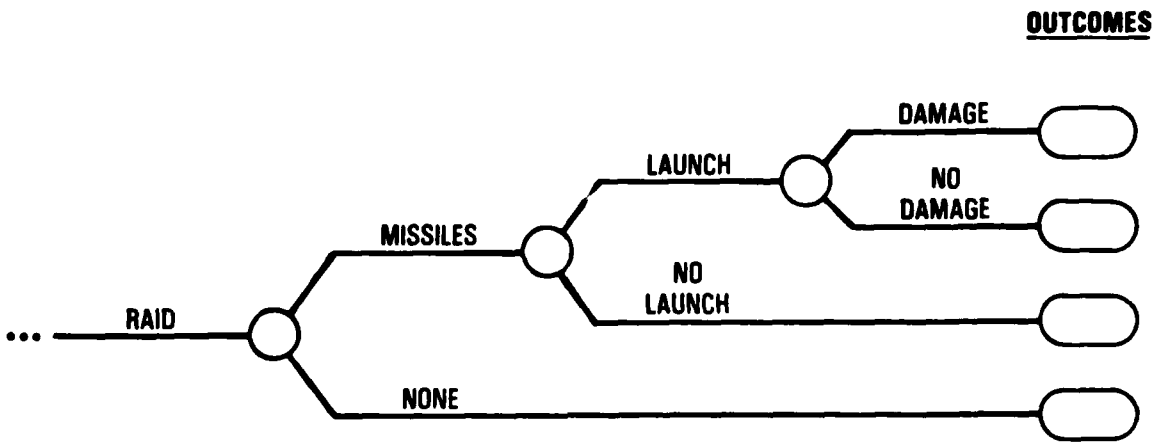

Figure 3-2
KEY UNCERTAINTIES — RAID

purchase information by using an agent leads to new key uncertainties and subsequent decisions as shown in Figure 3-3.

3.2.5 Event probabilities - DECISION also requires that the decision maker reflect the current state of knowledge concerning the relative likelihood of occurrence of the possible event outcomes. That knowledge may stem from many different sources, but it must be explicitly specified using probability as the standard measure of uncertainty. A probability is a number between 0 and 1, inclusive, that represents the extent to which an individual believes that a future event will occur. Probabilities are usually expressed as percentages of certainty: as 40% vice .4. Hence, the problem is to determine $P(E_i)$, the probability of the i^{th} outcome of event E, for all i. DECISION assumes that the event outcome probabilities are coherent: that is, that they are consistent with the user's state of knowledge

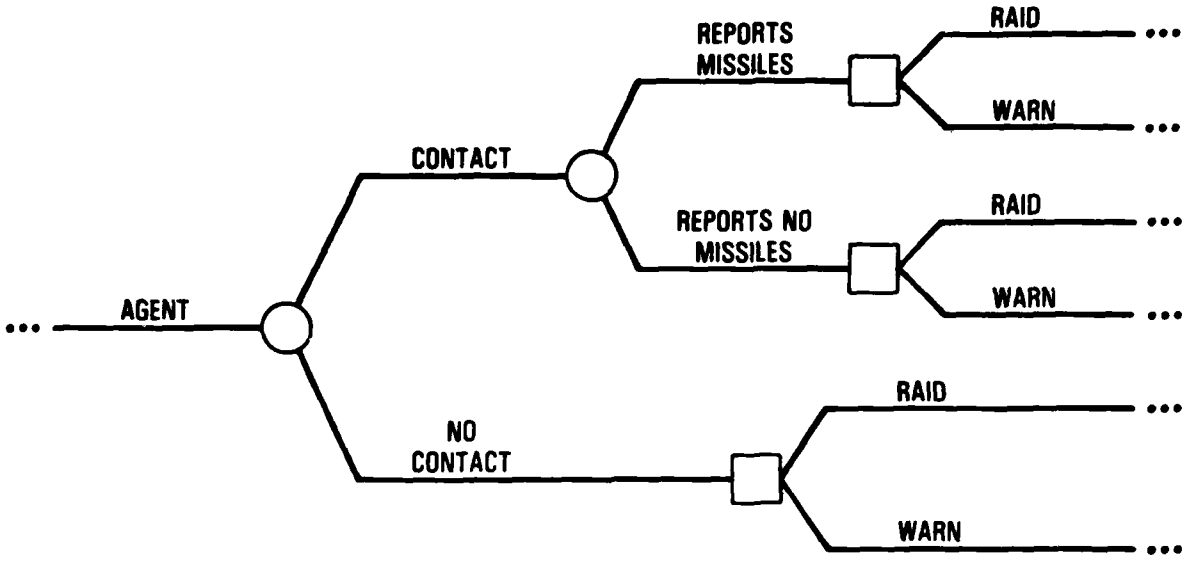

Figure 3-3
THE AGENT ALTERNATIVE

concerning future events as well as consistent with the laws of probability theory.

3.2.6 Decision outcomes - The logical flow of the decision tree model terminates with the decision outcomes. Figure 3-4 illustrates a partial decision tree for the RAMBO case. In the full tree there are 64 decision outcomes, each of which is a unique combination of decision alternatives and event outcomes.

3.2.7 Assessing decision outcomes - DECISION requires that the decision maker assess the relative utility, or degree of satisfaction, associated with each decision outcome. The process is difficult because several different criteria may be used in assessing the total utility of a decision outcome.

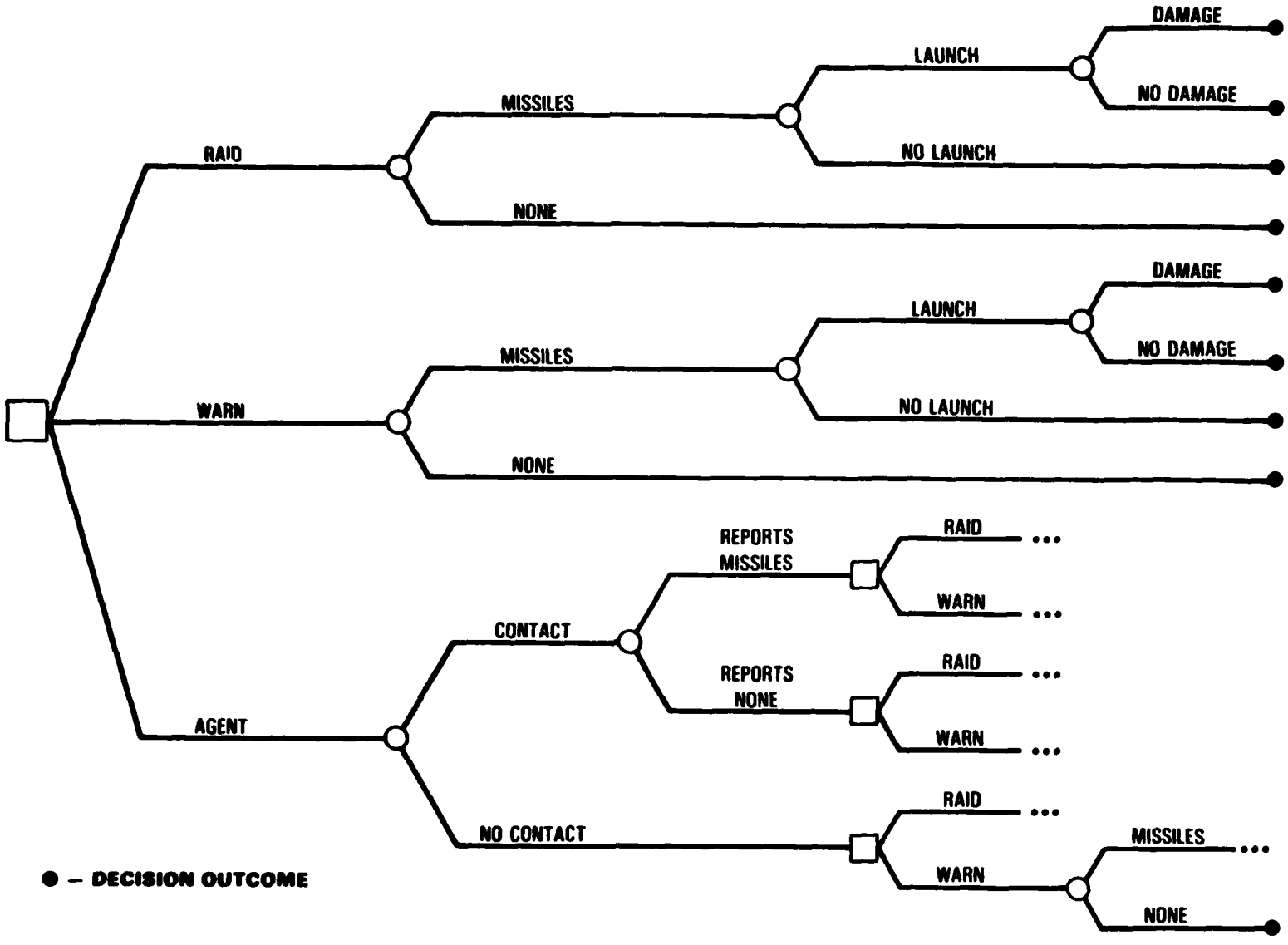

Figure 3-4

RAMBO DECISION TREE

Criteria. The first step in performing a utility assessment is to identify the criteria. In doing so, the decision maker must consider the multifaceted goals and objectives that pertain to the situation.

The criteria should be relatively independent, and they must effectively discriminate among the various decision outcomes. That is, the relative appeal of an individual decision outcome should be quite different when viewed from the standpoint of one criterion at a time.

Assume that in the RAMBO case the NCA is considering three criteria for success: the impact of the decision outcome on national security affairs, on domestic affairs, and on foreign affairs.

Criteria Weights. DECISION also requires that the criteria be assigned relative importance weights. In deriving those weights, the decision maker should examine each criterion with respect to its full range over all of the decision outcomes, considering the impact on that criterion of the difference between the best and worst outcomes. The criteria weighting issue is thus one that involves the relative importance of the variations in the possible outcomes with respect to each criterion.

For example, based on the best and the worst outcome scenarios regarding each criterion, the NCA might assign criteria weights of 50, 25, 25 for national security, domestic affairs, and foreign affairs, respectively.

Utilities. Once the criteria are identified, DECISION requires that a measure of utility, or degree of satisfaction, be assigned to each decision outcome. To facilitate the process, utilities are assigned to the

outcomes by considering the outcomes with respect to one criterion at a time. Utilities vary along a numerical scale ranging from 0 (no satisfaction) to 100 (maximum satisfaction).

For each decision outcome, the overall utility is the weighted sum of the individual criterion utilities. For example, if an outcome is assigned utility scores of 10, 80, 60 for national security, domestic affairs, and foreign relations, respectively, and the three criteria are weighted 50, 25, 25, then the overall satisfaction provided by the outcome is 40%. The overall utility score was derived by adding 50% of 10, 25% of 80, and 25% of 60.

A decision tree model is completely defined when all of the elements described above have been specified by the user.

4.0 RESULTS OF THE MODEL

The input specifications of the event outcome probabilities and the utilities of the decision outcomes can be processed by the DECISION software to produce a utility matrix that shows the expected utility at any desired node of the decision tree.

4.1 Utility Matrices

Presumably, the decision maker is most interested in the matrix that describes the overall utilities associated with the primary decision alternatives. The rational decision is to choose that primary decision alternative that leads to the greatest expected utility.

For example, Figure 4-1 displays a sample matrix that shows the overall result of interest for the decision tree shown in Figure 3-4. It depicts the total expected utility associated with each of the three primary courses of action: to raid, to warn, and to seek out an agent. Consistent with the overall results, the rational choice would be to warn, since that course of action leads to the greatest expected utility (70% satisfaction).

1 OVERALL RESULT

CRITERIA:	NAT-S	DOM-A	FOR-A	
CRIT. WEIGHTS:	50	25	25	TOTAL
1) RAID	80	42	51	63
2) WARN	62	74	81	70
3) AGENT	41	60	72	54

Figure 4-1
OVERALL RESULTS MATRIX

A matrix similar to that shown in Figure 4-1 can be produced for any desired node in the tree.

4.2 Computation of Results

DECISION computes the resultant utilities for any node by proceeding from right to left in the decision tree, beginning with the assessments of decision outcome utilities for each decision criterion and ending with the desired node. The computation process is known as folding back the decision tree.

The process of folding back a decision tree involves two different methods for combining utilities. The choice of method depends on the type of node: decision node or uncertain event node.

To illustrate the difference in computation, consider Figure 4-2, which shows a portion of the decision tree of Figure 3-4. The region shown in the figure contains one uncertain event node and two subsequent decision nodes. The event outcome probabilities (.76 and .24) are shown. Assume that the utilities shown at the right of the diagram (83, 42, 35, 64) have been correctly computed.

Proceeding from right to left, the next step is to compute the utilities of the two paths that lead to the two subsequent decisions; that is, to compute the utilities associated with the agent's reporting missiles and the agent's reporting no missiles. Those paths are properly assigned the utilities shown in Figure 4-3. Since both paths lead directly to a decision block, the computation process must assume a rational decision maker who, having arrived at the decision block, will always choose the path that leads to the greatest expected utility. That is, if the decision

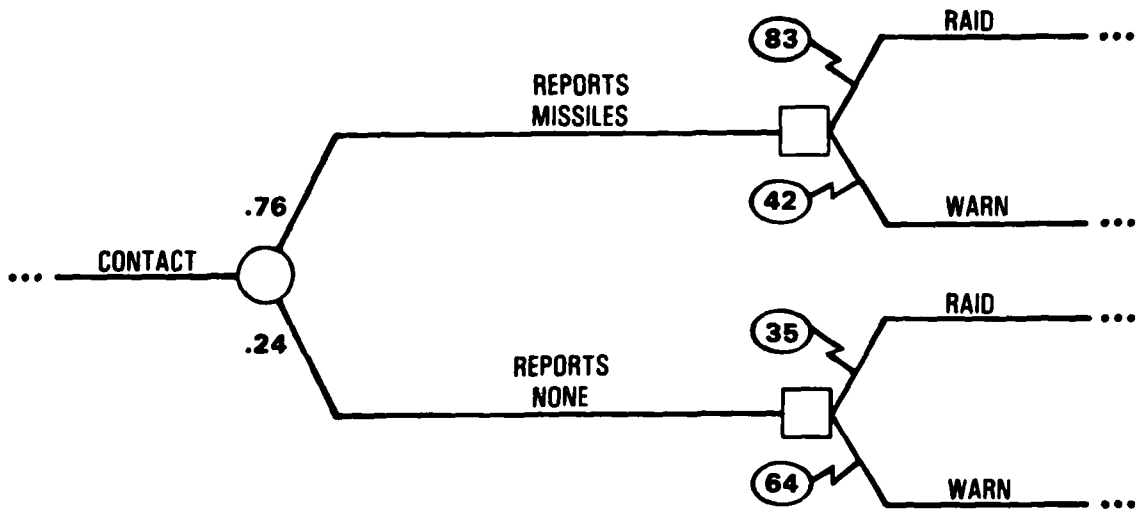

Figure 4-2
COMPUTING NODE UTILITIES

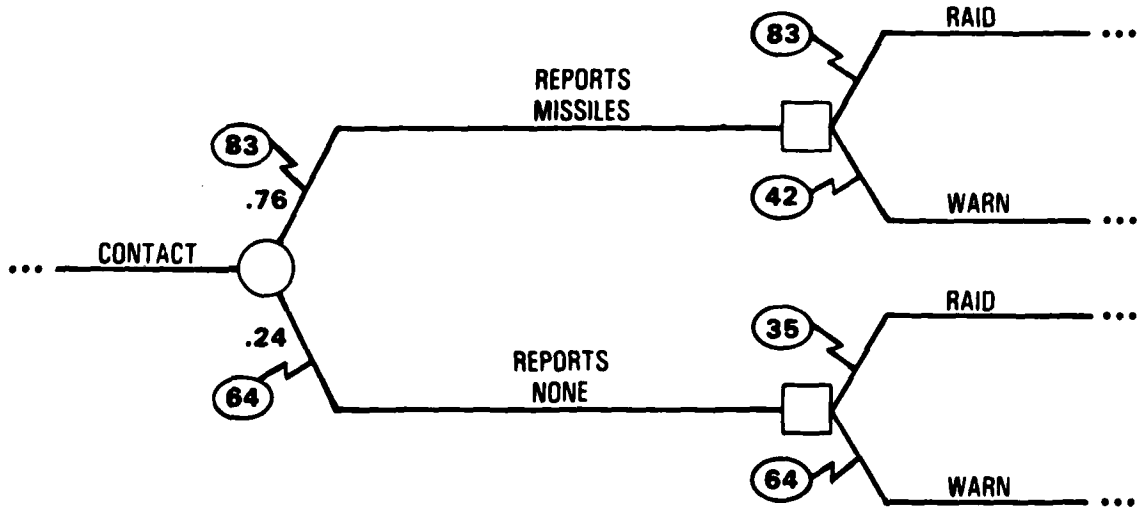

Figure 4-3
COMPUTING NODE UTILITIES

maker has indeed made contact with the agent and the agent has reported that missiles are present, then the rational decision maker would decide to raid, since the expected utility of doing so (83) far exceeds that of warning (42).

Thus, in the case of a decision node, the path leading to a subsequent decision is always assigned a utility value that is equal to the highest utility of the various decision alternatives.

Now consider the uncertain event node associated with the path in which the agent is contacted successfully (CONTACT). Note the assigned probabilities of the agent's possible responses. Figure 4-4 shows the utility (78) associated with the path leading to that uncertainty. The utility is the expected value of traversing that path. It is computed by multiplying the utility of each event outcome by the event outcome probability and summing the results. Thus, the expected utility of having contacted the agent is (83)(.76) + (64)(.24) = 78.44, which has been rounded off to 78 in the figure.

The same processes are repeated from right to left throughout the entire decision tree model until expected utilities have been computed for the primary decision alternatives.

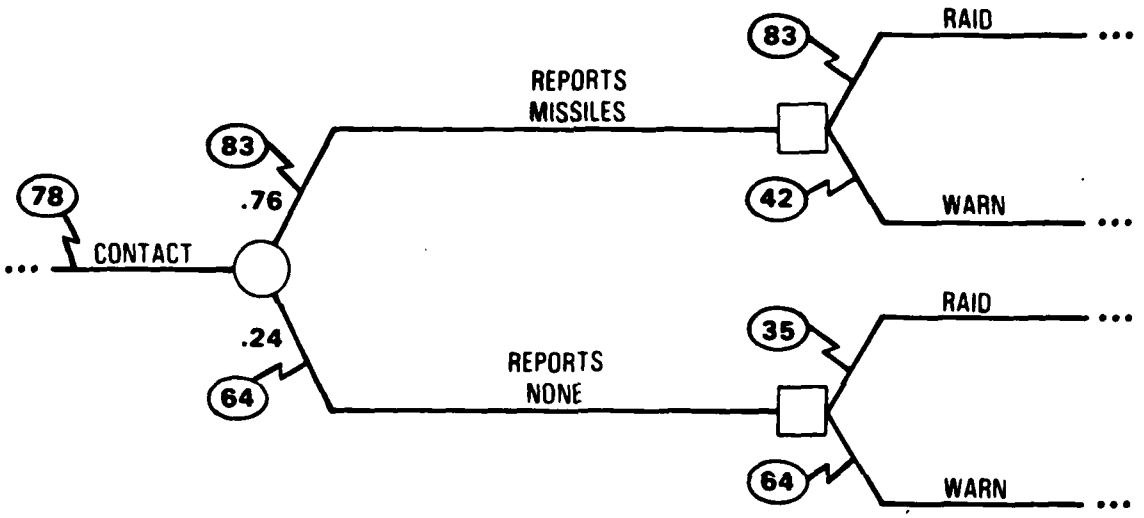

Figure 4-4
COMPUTING NODE UTILITIES

5.0 TECHNICAL OPERATIONS

This section explains how a user interfaces with the DECISION software. It assumes that a decision tree model exists in conceptual form, such as that shown in Figure 3-4.

5.1 Node Identification

DECISION requires that each node in the decision tree model be assigned an identification consisting of a node number, a label, and a designation as either a decision node or an event node. The node numbering scheme must be consistent in that node 1 must branch into nodes 1.1, 1.2, 1.3, ..., and so on. Similarly, node 1.3 must branch into nodes 1.3.1, 1.3.2, ..., etc. Note that for any node, the number of its immediately preceding node is specified by its identification number less the last digit. Thus, the node that precedes node 1.3.2.1.4 is node 1.3.2.1.

Each node must be assigned a short identifying label corresponding to the path leading to the node. The labels RAID, WARN, and AGENT are examples of appropriate identifying labels for nodes in Figure 3-4.

Finally, nodes must be designated by one of two letters: D or W. The letter D designates a decision node; the letter W designates an event (weighted) node. A typical identification of a node might be 1.1.2, NONE, W.

5.2 Subsystems

As shown in Figure 5-1, DECISION consists of two subsystems: STRUCTURE and RUN. The STRUCTURE subsystem is used to construct a new decision tree model or to revise the

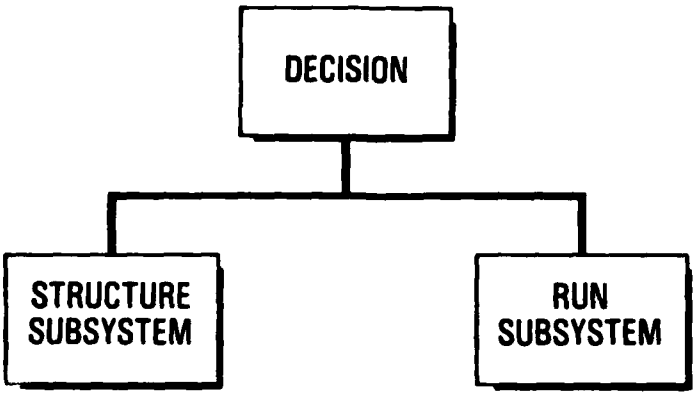

Figure 5-1
SUBSYSTEM ORGANIZATION

structure of an existing (computer-stored) decision tree model. The RUN subsystem is used to specify the criteria, weights, utilities, and probabilities for a newly created model, to edit the same for an existing model, and to display the overall results of the model. Each subsystem is loaded into the computer separately. Once the program is loaded, a menu of options will be displayed to the user. The user responds by selecting one of the options.

5.3 Option Menus

Both subsystems are hierarchically structured and menu-driven. At each level of the hierarchy, a menu of options is displayed to the user. Selection of any particular option will either cause an operation to be performed directly or it will result in the display of a secondary menu of options. If another menu appears and the user subsequently wishes to return to the previous menu, the user need only

return the carriage without selecting any specific option. With few exceptions, returning the carriage at any time (without inputting other instructions or making selections) will cause the computer to display the previous menu in the hierarchy. If the menu displayed is the one at the top of the hierarchy, returning the carriage will result in a query to the user regarding termination of the program.

The menu options for each subsystem will be discussed separately, beginning with the STRUCTURE subsystem.

5.4 The STRUCTURE Subsystem

When the STRUCTURE subsystem is loaded into the computer, the user is presented a primary menu of options to select. The primary menu provides a variety of tools with which to build and modify a decision tree model. The list of options presented by the primary menu is as follows:

- LOAD MODEL
- EDIT STRUCTURE
- CREATE OR ADD TO A STRUCTURE
- SAVE MODEL
- DEVELOP STRUCTURE
- CREATE BRANCH
- PRUNE SECTION
- PRINT REVIEW SHEET.

Each menu option is discussed below.

5.4.1 Load model - Selection of this option causes DECISION to display a secondary menu listing the names of the models that are currently stored. Selection of one of the model names causes DECISION to load the model into the computer's memory.

The user should select the LOAD model menu option only when it becomes necessary to make additions to or to otherwise edit an existing decision tree model. Once the selected model has been loaded, DECISION returns the user to the primary menu.

5.4.2 Edit structure - Selection of this menu option enables the user to make a variety of changes to the model that is currently stored in the computer's memory. Having selected this option, the user is requested to enter the identification number of the node that is to be edited; for example, the user might respond by typing: 1.1.2. DECISION responds by displaying the complete identification of the node (node number, label, and designator), which the user may change as desired.

The EDIT STRUCTURE option can be used to modify the structure by changing node identification numbers or deleting nodes as appropriate. Nodes are deleted by entering a blank line as the correction.

Editing the structure in this manner must be done with forethought and care to prevent creating two nodes with the same identification number and thereby inadvertently losing part of the original structure. Major restructuring should generally be done by first pruning the tree and then adding to the resulting tree to ensure that the changes made are as intended.

5.4.3 Create or add to a structure - This option can be used either to create an entirely new decision tree model or to add new nodes to an existing model. The computer first asks whether the operator intends to create a decision tree model. If the operator responds YES, then DECISION will request the names of the various criteria upon which

the utility of the decision outcome will be based and provides a set of brackets within which to type the first criterion name. After the first name is typed in, a second set of brackets will appear. After the final criterion name is entered, returning the carriage will result in the appearance of a number sign character (#). That indicates that the user is to enter the identification number for the first node in the tree.

The number character will appear immediately if the user should respond NO to the initial question, implying that the user does not wish to create a new model. The user must now enter the node number identification, the label, and the designator, being certain to place periods between the digits of the node number and to separate the number, title, and designator with a comma. If the comma is not inserted, the computer will display a statement to that effect and request that the operator reenter all of the identifying information.

If the set of branches succeeding the node comprises a decision point, the label must be followed by the designator D (decision node), separated by a comma. Otherwise, the designator W (weighted node) should be placed after the title, separated by a comma. The user continues this process until node identification numbers, labels, and designators have been entered for all of the nodes in the tree. The order of entry of the nodes is immaterial since STRUCTURE will organize them later into the proper sequence.

The first node in the tree is assigned any desired integer number; for example: 1. The branches from the original node are then numbered 1.1, 1.2, 1.3, and 1.4. Succeeding branches are numbered accordingly.

Another way to build a decision tree is to build the trunk of the tree and then add branches created using the CREATE BRANCH menu option explained later. The format for adding a branch is as follows: *BR 2 AFTER 1.2.1. This statement would follow the request for a node identification. The 2 referred to in the format is the branch identification number as originally assigned when using the CREATE BRANCH menu option; 1.2.1 is the number of the node directly preceding the branch. In this example, the first node of branch 2 would become node 1.2.1.1 in the structure. All nodes of branch 2 would receive new node numbers according to the same procedure. Therefore the same branch could be attached to several parts of the decision tree structure without assigning different node numbers each time the branch appeared.

5.4.4 Save model - This option provides the user a means of storing a model. In using the SAVE MODEL option, it is necessary that the user specify a model name. The name specified can be a new one or it can be the same name as an existing model. In the case of a new name, the model will be loaded into a storage file under that name and the name automatically added to the list of models available. If the user specifies the name of an existing model, the model currently stored under that model name will be replaced by the new model and the old model will be lost. That would normally be done when corrections have been made to an existing model and the new version replaces the old.

Two caveats are in order. First, if this menu option is not used, the current model will be lost whenever a new model is built or loaded or the computer turned off. Second, the model must be developed (as described later) before being saved.

5.4.5 Develop structure - This menu option is required to logically organize the node identification numbers, labels, and designators into the proper format to be used by the RUN subsystem. A decision tree model must be developed before it can be saved. No input data is required.

5.4.6 Create branch - This menu option enables the user to combine several nodes into a separate branch which later can be inserted into the overall tree as often as necessary using the CREATE OR ADD TO A STRUCTURE menu option. Creating a branch is particularly convenient when large parts of the tree are repeated several times, since it eliminates the need for extensive retyping.

After this option is chosen, DECISION asks for an arbitrary branch identification number. This number will be used to identify the branch wherever it is added to the structure. Therefore, each branch must be assigned a unique identification number. Assigning two branches the same identification number will cause the former to be lost.

After the branch identification number is typed in, the computer will ask whether the branch is new. If not, additions to the branch can be made in the same way as additions to the tree. Editing, however, must be done by retyping the entire node identification line.

If the branch is new, the user will be asked whether the branch is symmetric. A symmetric branch is one that has the same nodes succeeding each of the first level nodes, at all levels. A simple example of a symmetric branch is shown in Figure 5-2. For typing convenience, the user may identify a branch as symmetric even though it is not quite symmetric, but very close. That way, the branch may be added to the structure wherever necessary, and by

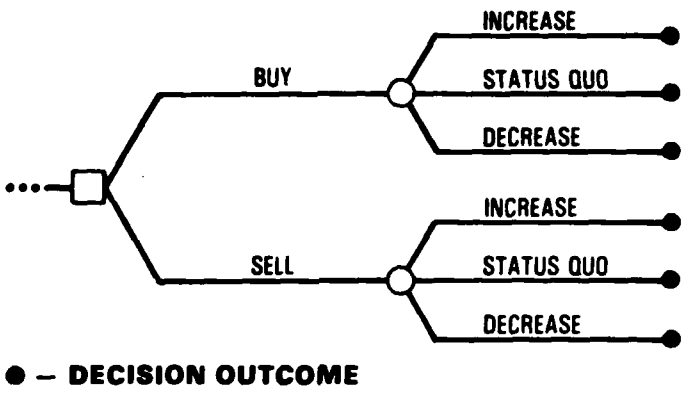

Figure 5-2
A SYMMETRIC BRANCH

follow-on editing or pruning (see the next section) the asymmetric portions can be corrected. That procedure will save substantial time in building the model.

If the user replies that the branch is not symmetric, the process of building the branch proceeds exactly as though a new decision tree were being created. Previously created branches may also be added to a new branch.

If the user replies that the branch is symmetric, the computer will then ask how many levels the branch will have. After receiving the appropriate response (in Figure 5-1, the response would be 2), the computer instructs the user to enter the labels for the first level (buy and sell). The procedure is repeated for the remaining levels.

5.4.7 Prune section - The PRUNE SECTION menu option enables the user to remove unwanted nodes from the tree. The computer requests the node identification number after which all remaining nodes are to be removed. The computer

double-checks the response with the user prior to pruning and afterwards displays the results of the pruning operation.

5.4.8 Print review sheet - Selecting this option enables the user to display and print out all of the nodes in the decision tree in numerical order. This procedure is useful as a check to ensure that all of the desired nodes have been entered, the proper identification numbers and designators assigned, and the labels are correct.

5.4.9 Probability tags - As a convenience to the user, DECISION permits the user to assign an identifying tag to all event nodes having identical outcome probabilities. The probability tag is an arbitrary letter of the alphabet placed after the D or W designator, separated by a comma. Probabilities assigned to a tagged event are automatically assigned to all events having the same tag. For example, if the two events shown in Figure 5-2 share the same outcome probabilities, they could be assigned the same tag.

5.5 The RUN Subsystem

When the RUN subsystem is loaded into the computer, the user is presented a primary menu of options to select. The primary menu provides a variety of tools with which to display and modify a decision tree model that was built using the STRUCTURE subsystem. The list of options presented by the primary menu is as follows:

- LOAD MODEL
- DISPLAY RESULTS
- WORK SHEET
- EDIT VALUES
- SAVE MODEL

- NEW VALUES
- EDIT CRITERIA WEIGHTS
- SHOW ALL.

Each menu option is discussed below.

5.5.1 Load model - The user must select the LOAD MODEL menu option in order to load the correct model into the computer's memory. Having selected this option, the user will be presented a list of all of the models available for loading and asked to select one model from the list.

5.5.2 Display results - Selecting this option results in a request for a node identification number. The user responds by typing the desired node identification number as originally assigned using the STRUCTURE subsystem. The expected value of utility at the specified node appears, along with its breakdown into the expected values of those events which immediately follow the examined node. In addition, the probabilities and cumulative probabilities of the uncertain events are displayed.

The DISPLAY RESULTS option is a passive option in that it only allows the user to display results previously stored in the model or calculations based on those results. It does not provide the user with a mechanism for changing any of these inputs and then generating new outputs. Such a revision must be accomplished by using the EDIT VALUES and EDIT CRITERIA WEIGHTS options.

5.5.3 Work sheet - Selecting this option produces a secondary menu which permits the user to request either a work sheet for probabilities or for utility scores. A work sheet listing the required probability or utility scores may be desired if the user requires a convenient form on which

to assess the appropriate values. Having the inputs arranged in an organized manner aids the data entry process significantly.

5.5.4 Edit values - This menu option produces a secondary menu which enables the user to modify the model in a variety of ways, by identifying the specific model elements for modification. The user can edit probabilities and utilities as described below.

Edit probabilities. Selecting this option produces a request for a node identification number. The number of the node which the user wishes to change should be typed in. The computer will then produce a display similar to the one shown by DISPLAY RESULTS. However, below this display will appear the words NEW PROBS followed by the current probabilities. The user edits probabilities by typing the new probabilities over the old ones. The computer will then normalize the values to sum to 100 and ask whether the normalized values are correct. If not, the process is repeated.

Edit values. This option allows the user to edit specific utility scores which have been input previously. The computer will request the node number of the utility scores to be changed. Only input nodes are appropriate for editing, since all other utility values are computed values. If the user specifies a non-input node, the computer will so indicate and then request another node number.

Edit probability tags. The user may edit the probabilities assigned to a tagged event node. All events having the same tag will be edited accordingly.

5.5.5 Save model - This menu option provides the user a means of storing a model permanently. In using the SAVE MODEL option, it is necessary that the user specify a model name. The name specified can either be a new one or it can be the same as a pre-existing model. In the case of a new name, the model will be stored under that name and the name automatically added to the list of models available. If the user specifies the name of an existing model, the model currently stored under that model name will be replaced by the new model, and the old model will be lost. That procedure is applicable when corrections have been made to an existing model.

Note that if the SAVE MODEL option is not used, the newly inputted values will be lost whenever a new model is built or loaded or the computer is turned off.

5.5.6 New values - Selecting this option produces a secondary menu asking if the user desires to load utility values or load probabilities. Choosing LOAD VALUES allows the user to input an entirely new set of utility scores. Similarly, the LOAD PROBABILITIES option allows the user to input an entirely new set of probabilities. In each case, the computer displays the appropriate nodes one by one, allowing the user to input values where necessary. The NEW VALUES option is used when the model has just been constructed and no values at all are in the model. If only a few values need to be changed, the EDIT VALUES option would be a preferred menu choice.

5.5.7 Edit criteria weights - This menu option allows the user to input or edit the criteria weights. New weights are entered by typing over the older values presented by the computer. The computer will then ask whether the user would like to have the criteria weights normalized to sum to 100

percent. Typing YES will yield normalized criteria weights, whereas typing NO will leave the original input intact.

5.5.8 Show all - This option causes all nodes that can be displayed using DISPLAY RESULTS to be printed on the line printer. It is especially useful if the user wishes to study the model in isolation from the computer, or if a compact printed set of results is necessary.

6.0 AN EXAMPLE OF THE USE OF THE DECISION SOFTWARE SYSTEM

This chapter presents a hypothetical decision analysis using the DECISION software system. It uses a hypothetical scenario to illustrate the procedures necessary to use DECISION and to demonstrate the various functions that DECISION provides. The scenario is an extension and modification of the RAMBO crisis scenario presented in Section 3.1.1.

6.1 A Hypothetical Scenario

Intelligence analysts have been concerned with the apparent introduction of defensive surface-to-air and offensive surface-to-surface missiles into the tiny island country of Rambo. The missiles, allegedly located in the small naval base at El Freba, pose a serious threat to nearby U.S. installations and transient aircraft.

The Premier of Rambo is a charismatic but fanatical leader who has denounced the U.S. endlessly for years. However, the pace, intensity, and specificity of his accusations have all increased markedly during the past two months.

Early this morning the Premier issued a lengthy, emotional, and bizarre worldwide proclamation accusing the U.S. of numerous recent deprivations and provocations, including an attempted assassination attempt on him. He threatened armed retaliation and mentioned "a rainbow of missiles." The proclamation has incited the Rambo citizens to a fever pitch. The government-controlled press is calling for offensive action. Volunteer reserve units of the Rambo Navy have spontaneously begun to report to the naval base at El Freba.

The U.S. National Command Authority (NCA) believes that if the missiles have in fact been introduced into Rambo, they will be used against U.S. installations and aircraft. The current intelligence estimate indicates a 60% probability that Rambo has missiles and the NCA believes there is a clear and present danger.

The NCA is now considering four immediate courses of action:

CA1 - RAID. Conduct a helicopter-borne night raid on El Freba; destroy all offensive weapons.

CA2 - WARN. Issue a stern public warning to Rambo that the missiles must be removed within 48 hours.

CA3 - WAIT. Do nothing; postpone the decision for 72 hours to await further developments.

CA4 - AGENT. Establish contact with an agent in Rambo. The agent is considered 80% reliable. However, this is a very dangerous course of action; there is only an even chance that the agent will be contacted successfully.

6.2 A Decision Tree Model

The first step in using DECISION is to develop the structure of a decision tree model that approximates the reality of the Rambo decision problem. Figure 6-1 is a representative decision tree. Note that the tree is built from left to right beginning with a decision node that branches into the four decision alternatives: RAID, WARN, WAIT, and AGENT. The first three alternatives each encounter a key uncertain event: whether or not missiles are actually present in Rambo. The combination of decision choice and event outcome defines a final outcome of the decision problem. For example, the second outcome on the far right of the tree is one in which the U.S. conducted a raid but no missiles were found.

In the case of the fourth decision alternative, AGENT, there is a key uncertain event (whether or not the agent will be contacted successfully) followed by still other event nodes and decision nodes. As before, a single path

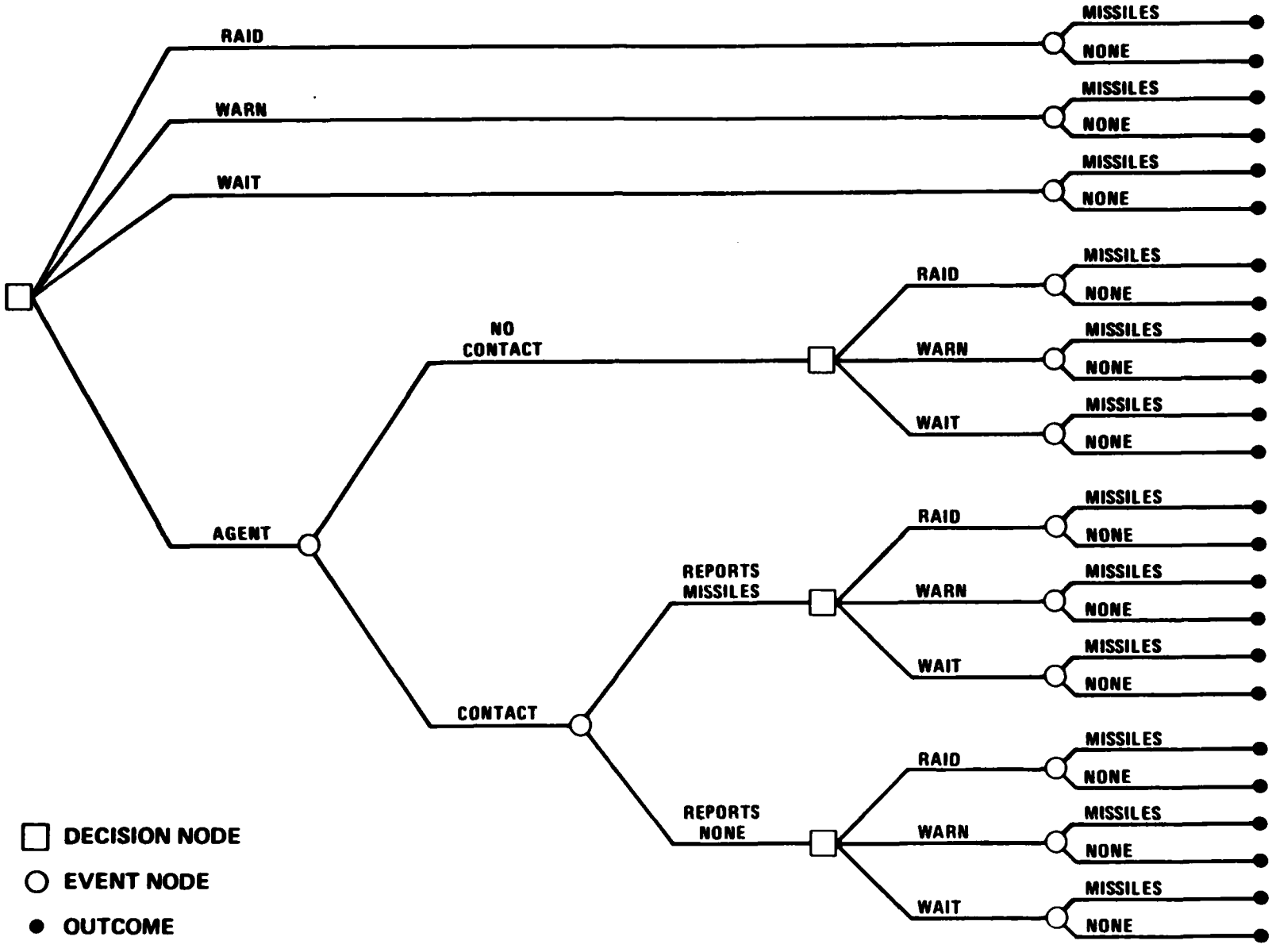

Figure 6-1

RAMBO DECISION TREE

through the decision tree defines a unique outcome of the problem. Note that Figure 6-1 displays twenty-four possible outcomes of the Rambo decision problem. Each outcome has a unique set of attributes against which the decision maker measures the degree of satisfaction toward a successful resolution of the problem.

Having developed a representative structure for the Rambo crisis, the user's next step is to add specifications to the model. First, the user must specify a logically consistent numbering scheme for the identification of the nodes in the tree. Second, probabilities must be specified for all of the uncertain event nodes. Finally, the user must specify the degree of satisfaction, or value of the overall utility to the decision maker, of each of the twenty-four outcomes.

Normally the attributes of the outcomes are measured against several different criteria for success. In the Rambo case, appropriate criteria would be the impact of the final outcome on national security, domestic affairs, and foreign affairs. The user must identify and define those criteria and their relative importance weights, and must specify the utility of each of the twenty-four decision outcomes with respect to each criterion.

Figure 6-2 shows a partially specified version of the Rambo decision tree. Node identification numbers and designators (D and W) are present, as are the probabilities of the key uncertainties. The probabilities shown in the figure are consistent with the statement of the problem and the laws of probability theory. The figure does not, however, indicate the utilities of the final outcomes.

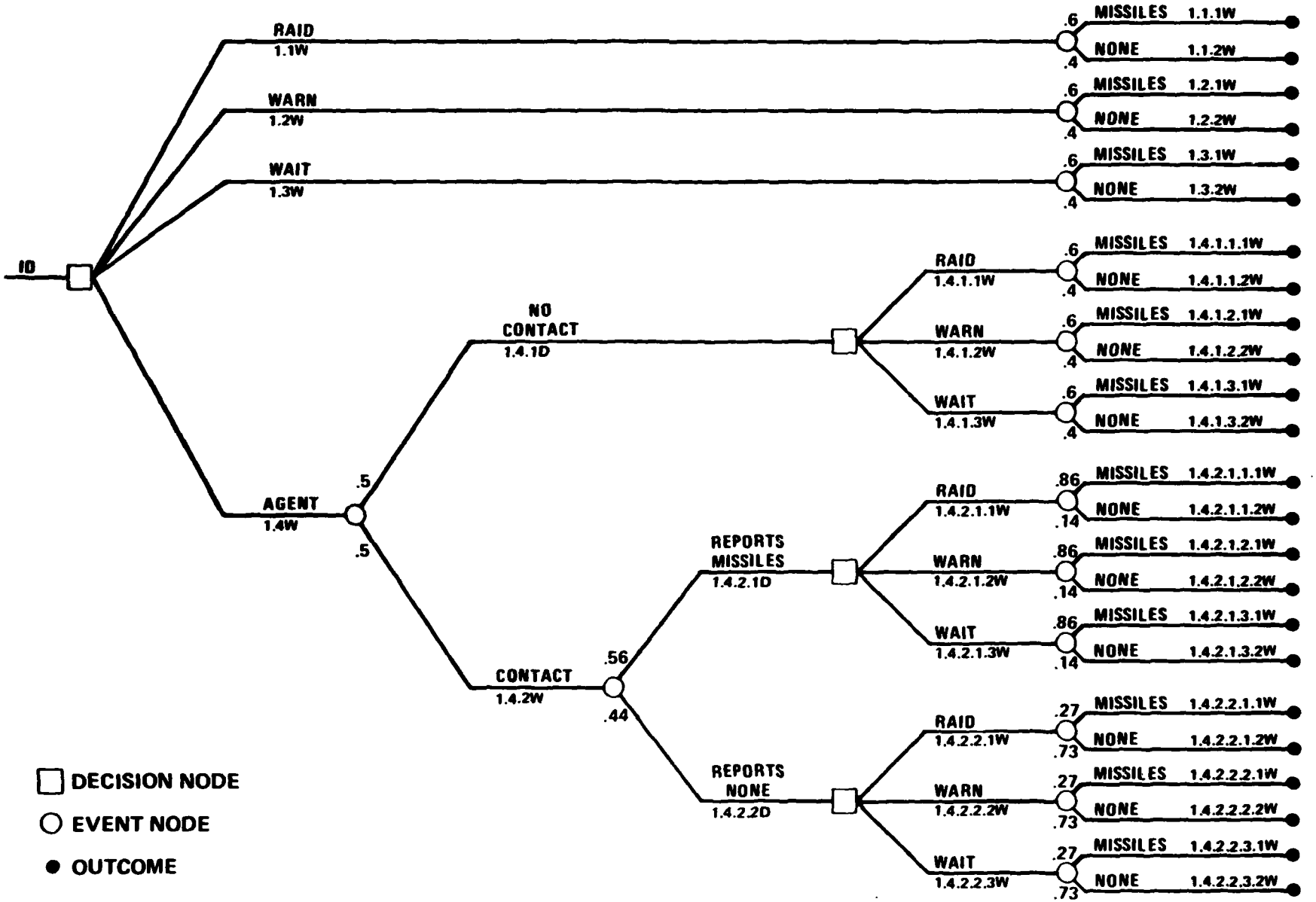

Figure 6-2

RAMBO DECISION TREE — SPECIFIED

6.3 Using the STRUCTURE Subsystem

At this point the user must create a computer representation of the decision tree. That is done by using the STRUCTURE subsystem in the manner described below.

6.3.1 Creating branches - Examination of Figure 6-2 discloses one repetitive decision tree branch: that shown in Figure 6-3. To avoid unnecessary effort in creating the structure, the user may create the branch shown in the figure and attach it to the tree where appropriate. In that regard, note that Branch 1 appears in four (not three) locations in Figure 6-2.

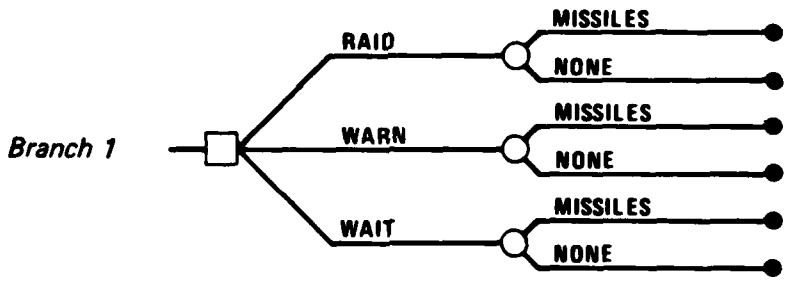

Figure 6-3
A DECISION TREE BRANCH

The user creates branches by selecting the CREATE BRANCH menu option of the STRUCTURE subsystem. The interactive exchange in creating Branch 1 is shown in Figure 6-4. User responses are underlined for clarity. Note that Branch 1 is a symmetric branch; the same two event outcomes

apply to each of the three decision alternatives. Figure 6-4 shows the interaction necessary to build Branch 1. User responses are underlined for clarity.

```
ENTER BRANCH IDENTIFICATION NUMBER:  1
IS THIS A NEW BRANCH?  Y
IS THIS A SYMMETRIC BRANCH?  Y
NUMBER OF LEVELS:  2
ENTER LABELS FOR LEVEL 1.
#: 1, RAID, W
W  RAID       1 0 0 0 0 0 0 0
#: 2, WARN, W
W  WARN       2 0 0 0 0 0 0 0
#: 3, WAIT, W
W  WAIT       3 0 0 0 0 0 0 0
#:
ENTER LABELS FOR LEVEL 2.
#: 1, MISSILES, W
W  MISSILES   * 1 0 0 0 0 0
#: 2, NONE, W
W  NONE       * 2 0 0 0 0 0
#:
```

Figure 6-4
CREATING BRANCH 1

6.3.2 Creating the tree structure - Having created the branch, the user next selects the CREATE OR ADD TO A STRUCTURE menu option. The user is then asked if the model is a new one. The user responds that it is, and is then asked to list the various criteria that will be used to evaluate the success of the decision outcomes. Following that, the user must specify the entire tree structure, adding Branch 1 where appropriate. The necessary interaction is shown in Figure 6-5. Note in particular how Branch 1 is integrated into the complete tree structure.

```
IS THIS A NEW MODEL?  Y
ENTER THE TITLES FOR EACH CRITERION
[NAT SEC ]
[DOM AFF ]
[FOR AFF ]
[        ]
#: 1, RAMBO, D
D  RAMBO       1 0 0 0 0 0 0 0
#: *BR 1 AFTER 1
#: 1.4, AGENT, W
W  AGENT       1 4 0 0 0 0 0 0
#: 1.4.1, NO CONTACT, D
D  NO CONTACT  1 4 1 0 0 0 0 0
#: *BR 1 AFTER 1.4.1
#: 1.4.2, CONTACT, W
W  CONTACT     1 4 2 0 0 0 0 0
*: 1.4.2.1, REP MISSLS, D
D  REP MISSILS 1 4 2 1 0 0 0 0
#: *BR 1 AFTER 1.4.2.1
#: 1.4.2.2, REP NONE, D
D  REP NONE    1 4 2 2 0 0 0 0
#: *BR 1 AFTER 1.4.2.2
#:
```

Figure 6-5
CREATING THE STRUCTURE

6.3.3 Reviewing the tree structure - Having created the structure, the user should next select the PRINT REVIEW SHEET menu option to obtain a complete listing of the model. A representative output from this option appears in Figure 6-6.

6.3.4 Changes to the model structure - Having reviewed the model structure, the user may want to initiate changes. Changes are made either by the EDIT STRUCTURE or the PRUNE SECTION or the CREATE OR ADD TO A STRUCTURE menu options.

The EDIT STRUCTURE option permits the user to make changes to the identification labels and designators of any existing node in the model. The PRUNE SECTION option

```
1 RAMBO D
1 1 RAID W
1 1 1 MISSILES W
1 1 2 NONE W
1 2 WARN W
1 2 1 MISSILES W
1 2 2 NONE W
1 3 WAIT W
1 3 1 MISSILES W
1 3 2 NONE W
1 4 AGENT W
1 4 1 NO CONTACT D
1 4 1 1 RAID W
   .
   .
   .
1 4 2 2 3 WAIT W
1 4 2 2 3 1 MISSILES W
1 4 2 2 3 2 NONE W
```

Figure 6-6
REPRESENTATIVE REVIEW SHEET

permits the user to remove any node (and all nodes attached to it) from an existing model. The CREATE OR ADD TO A STRUCTURE option permits the user to add new nodes to an existing model.

6.3.5 The use of probability tags - Note that the user could have used, but chose not to, probability tags to denote those event nodes having the same event outcome probabilities. If tags had been used then, referring to Figure 6-2, the following node tag assignments would have been appropriate:

TAG A	TAG B	TAG C
1.1	1.4.2.1.1	1.4.2.2.1
1.2	1.4.2.1.2	1.4.2.2.2
1.3	1.4.2.1.3	1.4.2.2.3
1.4.1.1		
1.4.1.2		
1.4.1.3		

In this example the user chose not to assign tags because of the convenience of defining branch 1 and attaching it to the main tree in four places. Note that if tags had been assigned then branch 1 (with tag A) could only be attached in two places.

6.3.6 Completing the model - At this point the user must prepare the model for the RUN subsystem. That is done by selecting the DEVELOP STRUCTURE menu option followed by the SAVE MODEL option. The computer will request a name to be used for the storage of the model. If the user should choose an existing name, the computer will so inform the user. If the user persists with the same name, the stored model of the same name will be replaced by the new one.

The user is now ready to use the RUN subsystem.

6.4 Using the RUN Subsystem

At this point the user has created the basic structure of the decision tree model but has not yet input the values of utility and probability that apply to the appropriate nodes of the tree. Those values are input using the RUN subsystem. The RUN subsystem is also used to display the final results of the model. The use of the RUN susbystem is described below.

6.4.1 Loading the model - The user must begin by loading the model of interest into the computer. That is done by selecting the LOAD MODEL option from the primary menu of options displayed by the RUN software. Having selected the LOAD MODEL option, the user is shown a list of the models available for loading and asked to select one. In order to complete the specification of the Rambo model,

the user must select that model to be loaded. RUN then returns the user to the primary menu of options.

6.4.2 Using a work sheet - The user may wish to record the probabilities of the uncertain event outcomes and the utilities of the twenty-four decision outcomes off-line. That is, the user may wish to leave the interactive mode to concentrate on the values to be assigned. RUN provides two logically organized work sheets for this purpose. One addresses the probabilities of the uncertain events; the other addresses the utilities of the final decision outcomes with respect to each criterion. Figures 6-7 and 6-8 are representative work sheets for the Rambo model.

Note that the work sheets are organized in the same order in which the data must be entered into the computer.

6.4.3 Entering values - The user is now ready to enter the values of probability and utility. Those entries are made by selecting the NEW VALUES menu option. Having selected that option, the user is presented a secondary menu having two options: LOAD VALUES and LOAD PROBABILITIES. Each should be selected in turn.

The user must also enter the importance weights of the three criteria: national security, domestic affairs, and foreign affairs. As discussed in Section 3.2.7, the importance weights should be based on the relative difference between the best and worst possible outcomes with respect to each criterion. The importance weights should not be based on some generalized notion of the absolute importance of the criteria. That is, the importance weights to be assigned depend on the twenty-four specific outcomes of the Rambo crisis and the range of impact of those outcomes on the criteria.

	DOM-A	FOR-A	NAT-S
1 RAMBO D			
1 1 RAID W			
1 1 1 MISSILES W	____	____	____
1 1 2 NONE W	____	____	____
1 2 WARN W			
1 2 1 MISSILES W	____	____	____
1 2 2 NONE W	____	____	____
1 3 WAIT W			
1 3 1 MISSILES W	____	____	____
1 3 2 NONE W	____	____	____
1 4 AGENT W			
1 4 1 NO CONT D			
1 4 1 1 RAID W			
1 4 1 1 1 MISSILES W	____	____	____
1 4 1 1 2 NONE W	____	____	____
1 4 1 2 WARN W			
.			
.			
.			
1 4 2 2 REP NONE D			
1 4 2 2 1 RAID W			
1 4 2 2 1 1 MISSILES W	____	____	____
1 4 2 2 1 2 NONE W	____	____	____
1 4 2 2 2 WARN W			
1 4 2 2 2 1 MISSILES W	____	____	____
1 4 2 2 2 2 NONE W	____	____	____
1 4 2 2 3 WAIT W			
1 4 2 2 3 1 MISSILES W	____	____	____
1 4 2 2 3 2 NONE W	____	____	____

Figure 6-7

UTILITY WORK SHEET

1.1 - RAID
1) MISSILES _____
2) NONE _____

1.2 - WARN
1) MISSILES _____
2) NONE _____

1.3 - WAIT
1) MISSILES _____
2) NONE _____

1.4 - AGENT
1) NO CONT _____
2) CONT _____

.
.
.

1.4.2.2.3 - AGENT-CONTACT-REP NONE-WAIT
1) MISSILES _____
2) NONE _____

Figure 6-8
PROBABILITY WORK SHEET

Importance weights are entered by choosing the EDIT CRITERIA WEIGHTS menu option. The weights may be entered in an absolute form, such as 60 40 100, which the computer will then normalize to sum to 100; to continue the example: 30 20 50.

6.4.4 Editing values - The user may have entered the values of probability and utility incorrectly or wish to update certain values. Changes are made by selecting the EDIT VALUES menu option. Selection of that option causes a secondary menu to be displayed, as follows: EDIT PROBABILITIES, EDIT VALUES, and EDIT PROBABILITY TAGS. Having selected one of the three secondary options, the user must identify the node to be edited. RUN displays the current

value assigned to the node and allows the user to modify the value as required.

6.4.5 Displaying results - Having completely specified the decision tree model, the user may display the values of expected utility at any node in the tree. That is done by selecting the DISPLAY RESULTS option of the primary menu. RUN will then request the identification number of the node to be displayed.

A typical result matrix is shown in Figure 6-9. The figure shows the overall result; that is, the overall expected utility of each course of action at node 1. Figure 6-9 indicates that, consistent with the probabilities, utilities, and criteria importance weights specified by the user, the rational choice should be to raid. The raid alternative provides an expectation of achieving 63% satisfaction while the next-best alternative, to use an agent, provides an expectation of achieving 51% satisfaction across the three criteria for success.

1 RAMBO

CRITERIA:	DOM-A	FOR-A	NAT-S	TOTAL
CRIT. WEIGHTS:	30	20	50	
1) RAID	42	55	78	63
2) WARN	48	59	43	48
3) WAIT	58	72	35	50
4) AGENT	61	60	41	51

Figure 6-9
OVERALL RESULT

The user can display the results at any node in the tree. For example, Figure 6-10 shows the intermediate results at node 1.4.2 of the Rambo decision model.

1.4.2 - RAMBO-AGENT-CONTACT

BRANCH PROB.	NAT-S	DOM-S	FOR-A	TOTAL
CRIT. WEIGHTS:	50	25	25	
1) REP MISSLS (56)	81	62	70	74
2) REP NONE (44)	17	22	41	24

Figure 6-10
INTERMEDIATE NODE RESULTS

The user can cause a complete set of the result matrices to be printed out by selecting the SHOW ALL primary menu option.

6.4.6 Saving the model - Having completely specified the decision tree model, the user might want to save it for further review and refinement. The model is saved by selecting the SAVE MODEL menu option.

As in the case of the STRUCTURE subsystem, the user must specify a name for the storage of the model. If the name is currently in use, the user is so advised and permitted to change the name. If the user persists, the previous model of the same name will be replaced by the current model. Otherwise, the new model is added to the library of models.

7.0 ABRIDGED USERS MANUAL

This section is designed for the user who is already familiar with the DECISION software. It lists the essential elements of a decision tree model and then discusses how those elements are molded into a DECISION model by using the two subsystems: STRUCTURE and RUN.

7.1 Organizing the Decision Problem

The user must organize the decision problem as a decision tree model in the form shown conceptually in Figures 2-1 and 2-2. The decision tree model must include all of the following elements:

- a hierarchical node identification scheme (labels, numbers, designators, and tags) as discussed in Section 5.1;
- event probabilities;
- a list of the decision outcome criteria;
- the utility of each outcome with respect to each criterion; and
- the relative importance weights of the criteria.

7.2 Structuring the Model

The user structures the decision tree model by first using the STRUCTURE subsystem. When the STRUCTURE software is loaded into the computer, the user exercises the system by selecting from the following list of options.

7.2.1 STRUCTURE menu options -

LOAD MODEL - To retrieve a previously structured model from the model library.

EDIT STRUCTURE - To alter the identification of the nodes of an existing model.

CREATE or ADD TO A STRUCTURE - To construct a new model or add additional nodes to an existing model. This option also elicits the decision outcome criteria for a new model.

SAVE MODEL - To store a newly created or revised model in the model library.

DEVELOP STRUCTURE - To prepare a newly created model for use by the RUN subsystem.

CREATE BRANCH - To create one or more repetitive branches of a larger tree. The branches may be symmetric or not. Each branch may be attached to a tree in multiple locations by using the CREATE OR ADD TO A STRUCTURE option.

PRUNE SECTION - To remove nodes and branches from an existing model.

PRINT REVIEW SHEET - To print a hierarchically organized listing of all of the nodes of a model.

Having completed the hierarchical structure of the model by using the STRUCTURE subsystem, the user must then specify probabilities and utilities by using the RUN

subsystem. Note that a newly structured or edited model must be developed using the DEVELOP option and saved using the SAVE MODEL option before it can be utilized by the RUN subsystem.

Having loaded the RUN software into the computer the user exercises the system by selecting from the following list of options.

7.2.2 RUN menu options -

LOAD MODEL - To retrieve a previously structured model from the model library.

DISPLAY RESULTS - To display the expected utilities at any specified node in the tree.

WORK SHEET - To print out a work sheet on which to manually record the event probabilities and the decision outcome utilities.

EDIT VALUES - To change previously assigned values of probability and utility.

SAVE MODEL - To store a newly created or revised model in the model library.

NEW VALUES - To enter a complete set of probabilities and utilities.

EDIT CRITERIA WEIGHTS - To enter or to change the relative importance weights of the decision outcome criteria.

SHOW ALL - To print out a complete listing of the expected utility at each node of the tree.